

## Altair Optimization Contest 2021

# Multi-Objective Design Optimization of Bladeless Wind Generator

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# 1. Introduction



Figure 1 conventional wind power generator

## Problems of Conventional Wind Power Generators (WPG)<sup>1)</sup>

### Issue

- Occurrence of bird strikes per year
- Increased maintenance cycle of conventional WPG
- Limited installation site of conventional WPG

### Result

- High maintenance cost
- Low resident acceptance of WPG



Figure 2 Bladeless wind generator

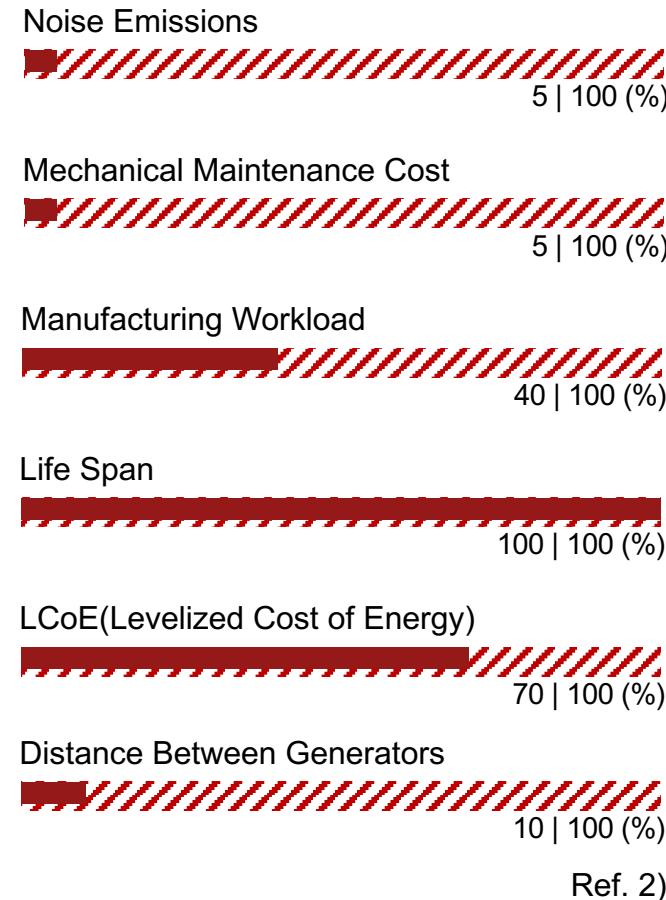


Figure 3 conventional wind power generator

**The Bladeless wind generator(BWG)** is more efficient than a conventional wind power generator

# Bladeless Wind Generator (BWG)



Figure 4 Bladeless wind generator



Figure 5 Bladeless wind generator

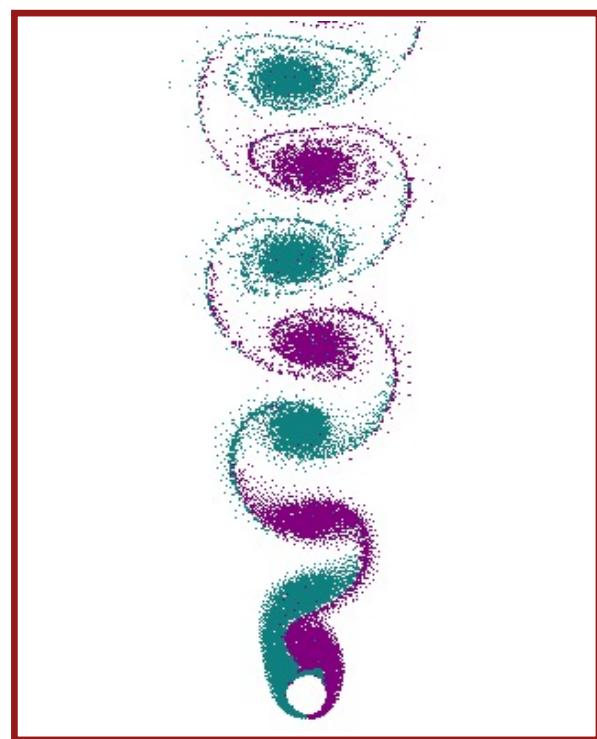


Figure 6 Vortex shedding

**BWG** is a renewable energy system using vortex generated by wind consisting of a simple structure (rod with CFRP and mast with glass fiber)

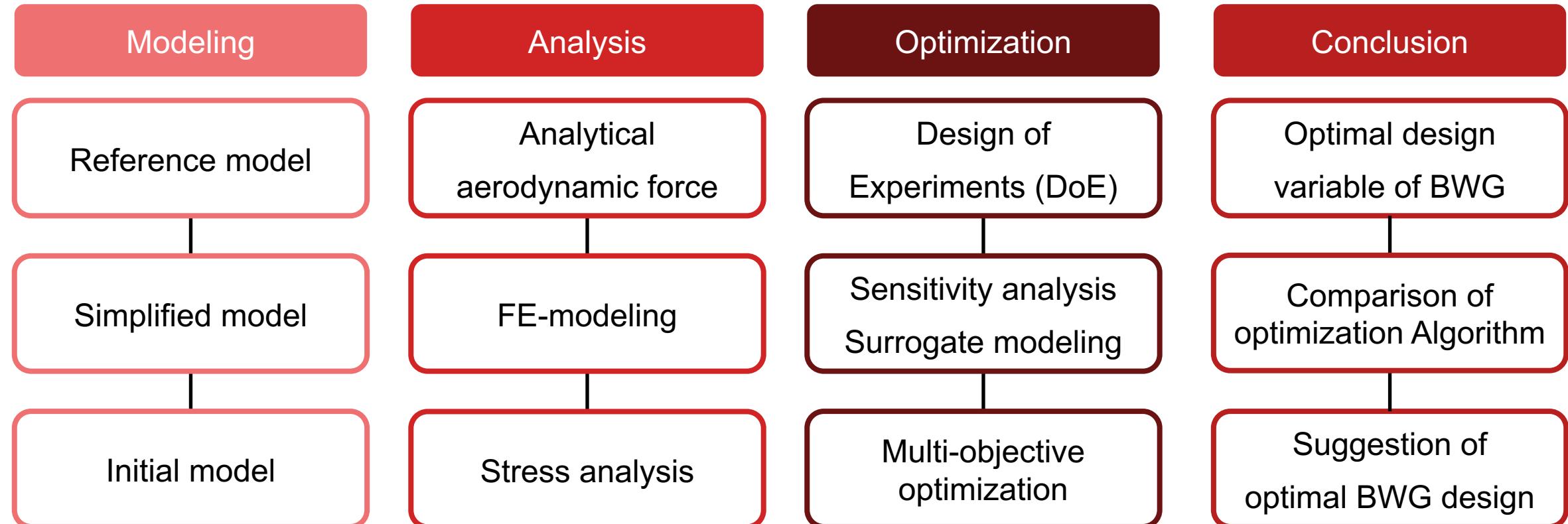
# Optimal Design Procedures

## Introduction

## Modeling

## Analysis & Optimization

## Conclusion



# 2. Modeling

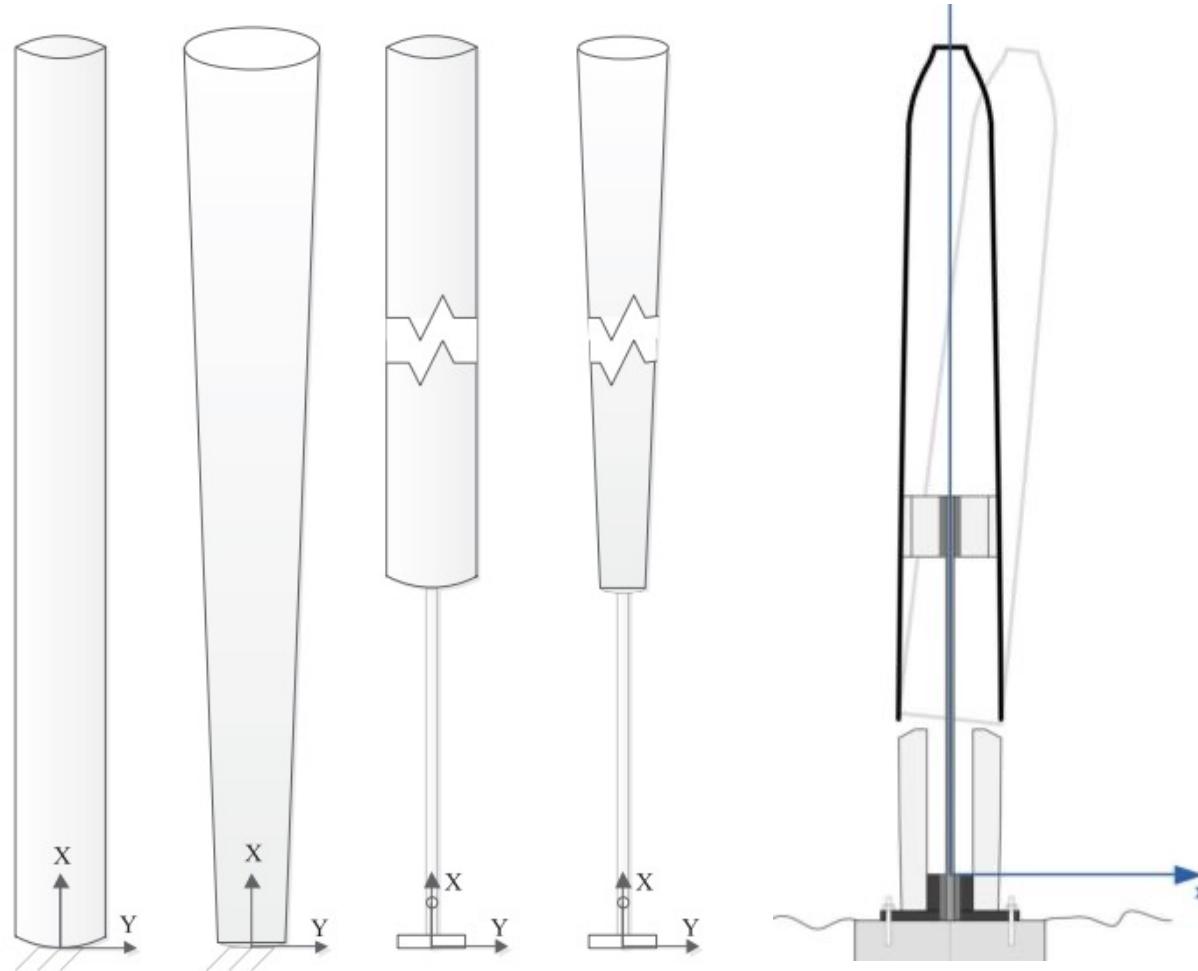
# Initial model

Introduction

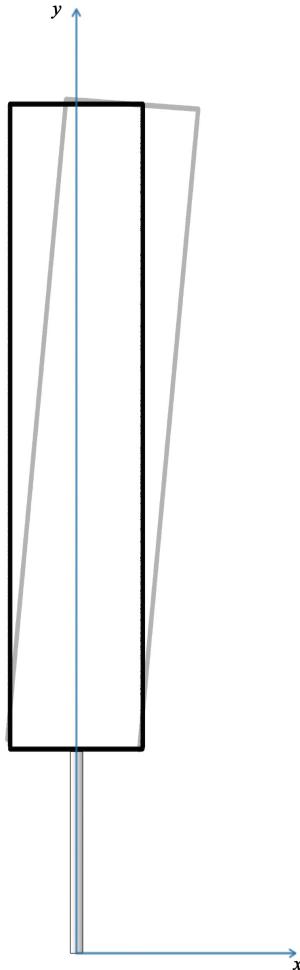
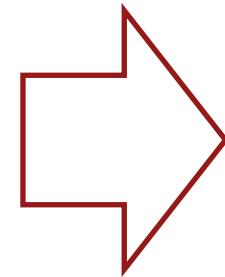
**Modeling**

Analysis & Optimization

Conclusion

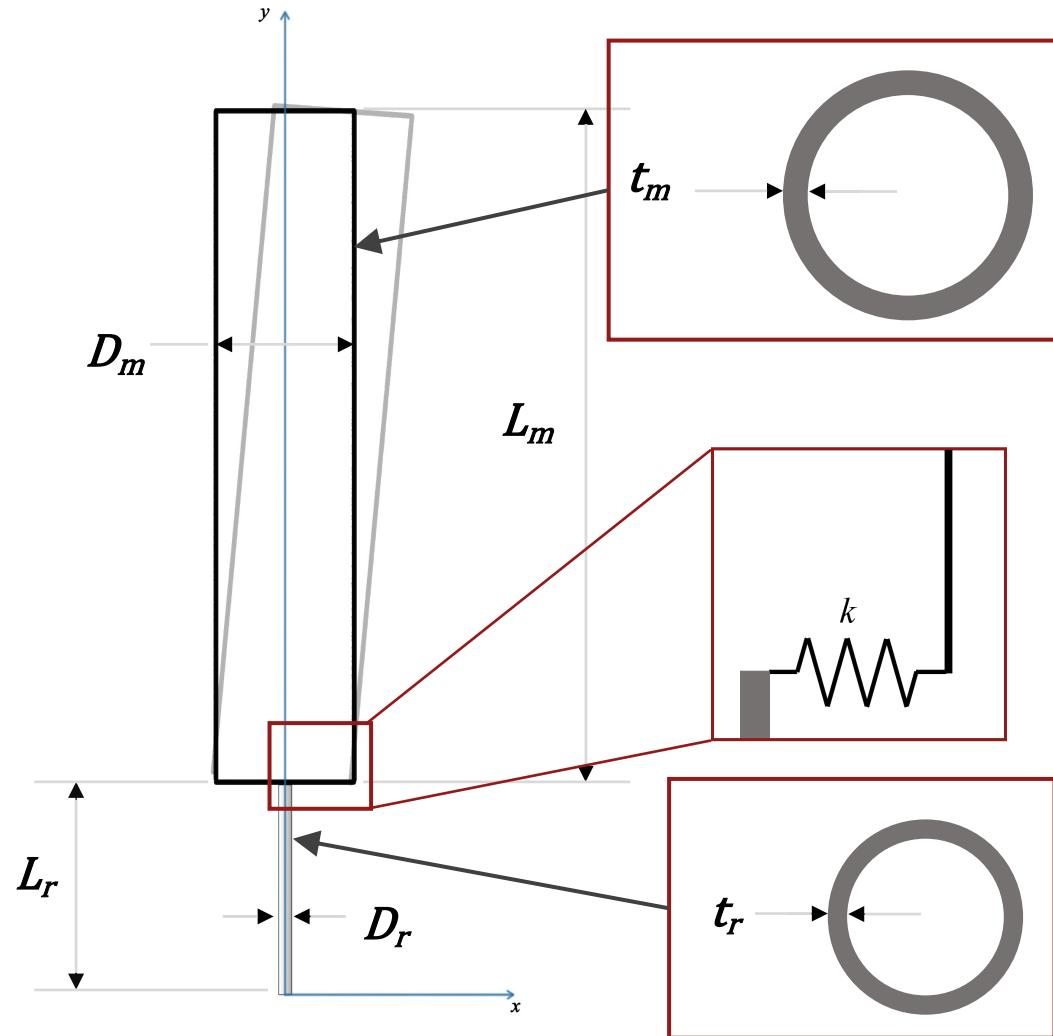


Reference model <sup>3)4)</sup>



Simplified model

# Initial model



| Variable | Description                 | Value                   |
|----------|-----------------------------|-------------------------|
| $L_r$    | Rod length                  | 1.0000m                 |
| $L_m$    | Mast length                 | 4.0000m                 |
| $D_r$    | Rod diameter                | 0.0200m                 |
| $D_m$    | Mast Diameter               | 0.6000m                 |
| $t_r$    | Rod thickness               | 0.0020m                 |
| $t_m$    | Mast thickness              | 0.0020m                 |
| $k$      | Spring stiffness            | 100.0N/m                |
| $V$      | Velocity                    | 2.000m/s                |
| $E_r$    | Rod young's modulus (CFRP)  | 14.50GPa                |
| $E_m$    | Mast young's modulus (GFRP) | 72.00GPa                |
| $\rho_r$ | Rod mass density (CFRP)     | 19,000kg/m <sup>3</sup> |
| $\rho_m$ | Mast mass density (GFRP)    | 2,575kg/m <sup>3</sup>  |
| $S$      | Strouhal number             | 0.2100                  |
| $C_d$    | Drag coefficient            | 1.0000                  |

# 3. Analysis & Optimization

# Analysis

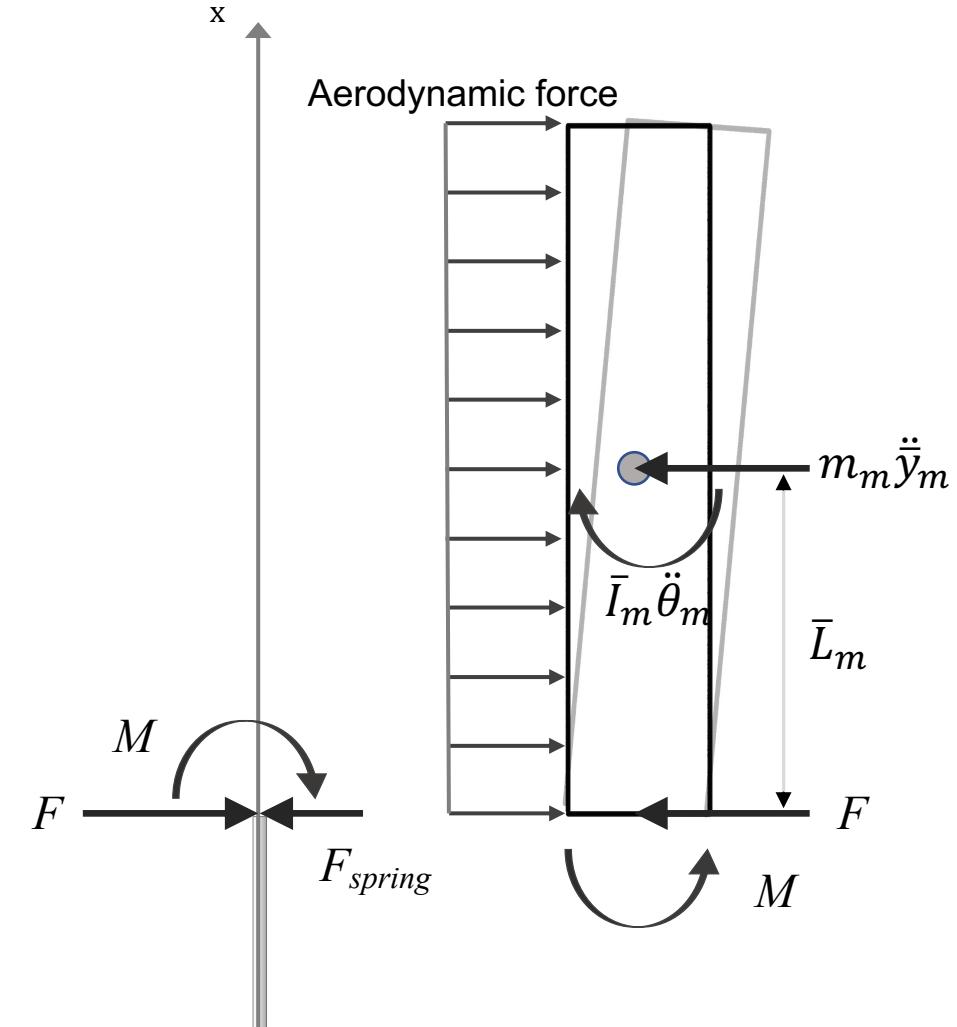
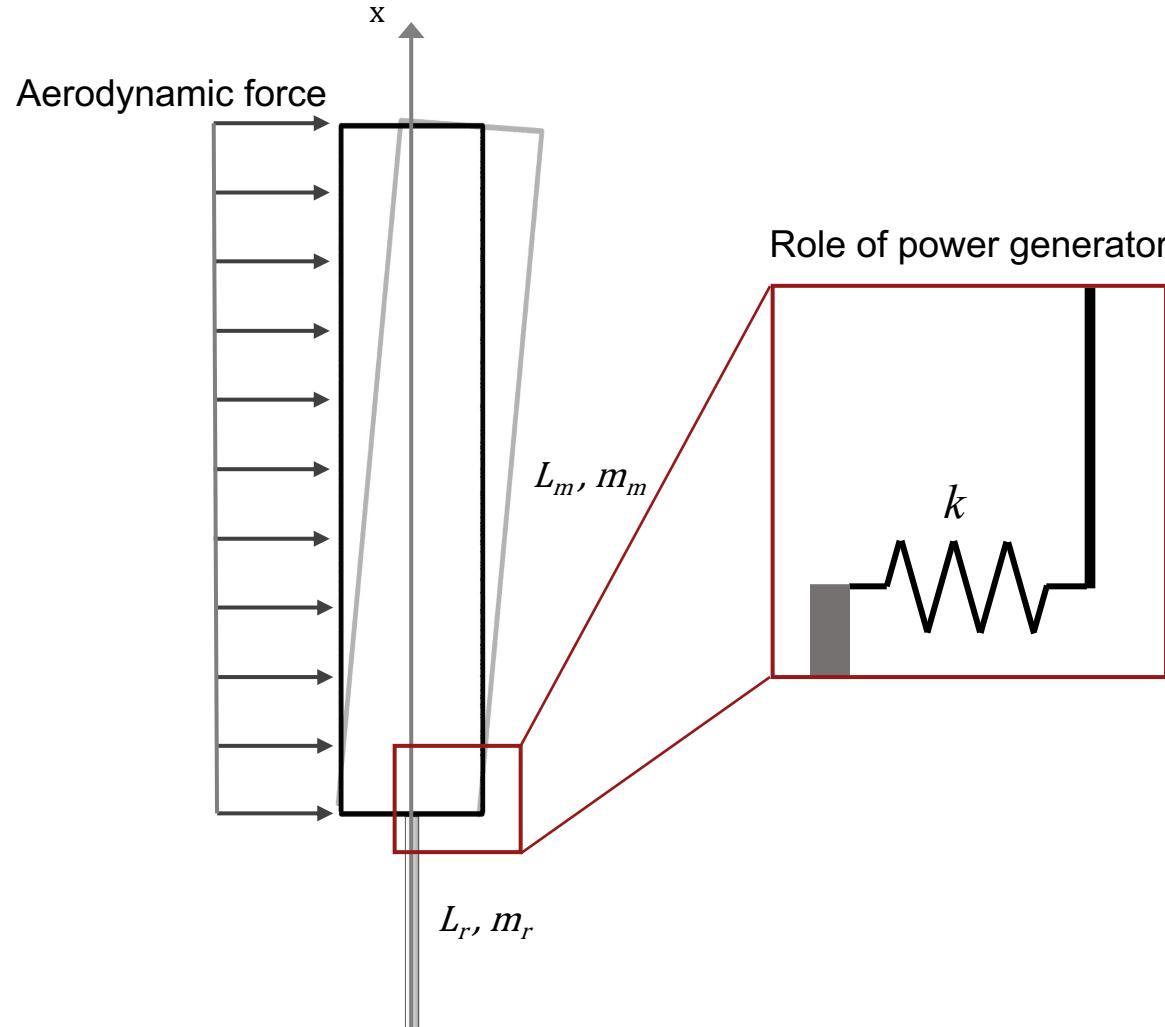
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## Free body diagram



# Analysis

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## Analytical aerodynamic force<sup>4)</sup>

$$F_0(x) = \frac{1}{2} \rho V^2 C_D D_m(x)$$

$$F = \int_{L_r}^{L_r + L_m} \frac{1}{2} \rho V^2 C_D D_m(x) dx - m_m \ddot{y}_m$$

where,  $D_m(x) \sim D_m$

$$M = \int_{L_r}^{L_r + L_m} \frac{1}{2} \rho V^2 C_D D_m(x)(x - L_s) dx - m_m \bar{L}_m \ddot{\bar{y}} - \bar{I}_m \dot{\theta}_m$$

$\rho$  : Air density (Kg/m<sup>3</sup>)

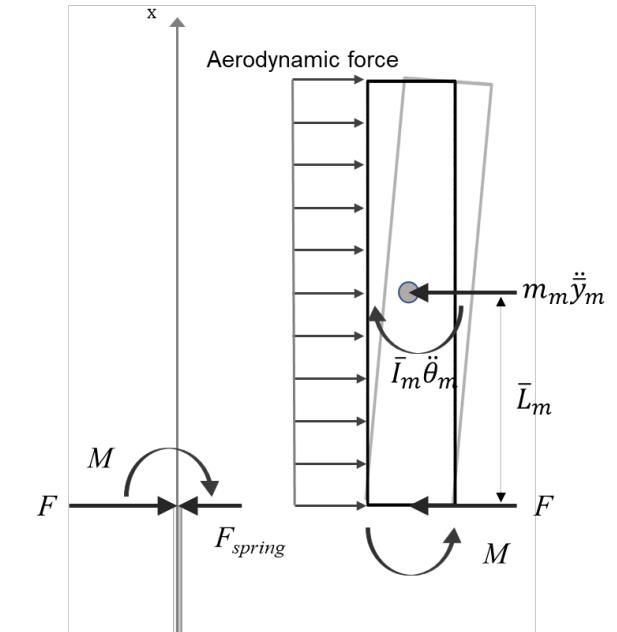
$V$  : Velocity (m/s)

$C_D$  : Drag coefficient

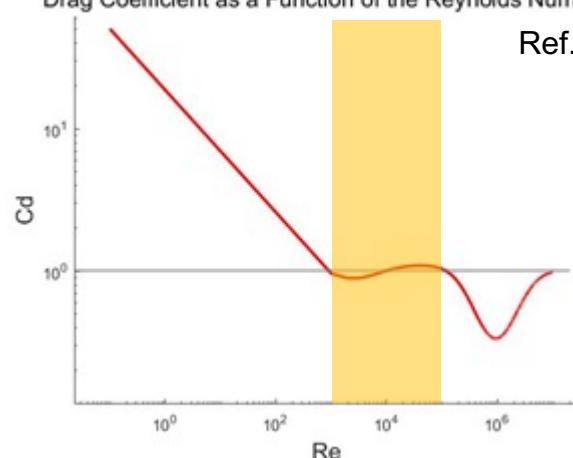
$D_m$  : Mast diameter (m)

$L_r$  : Rod length (m)

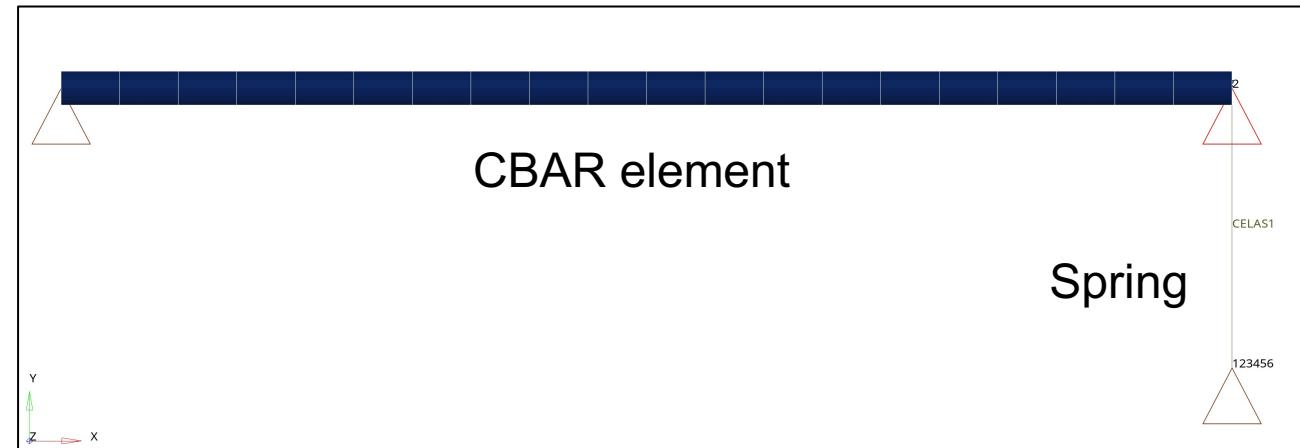
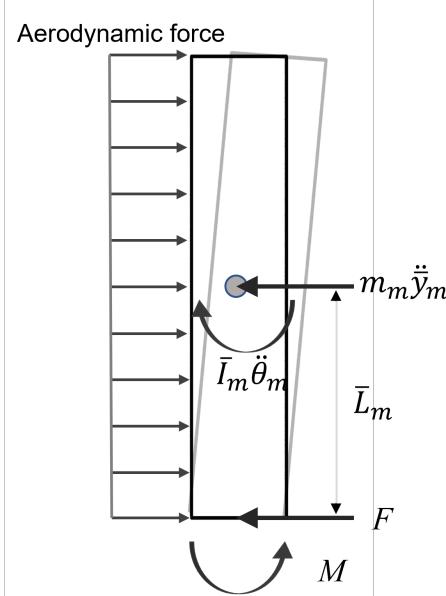
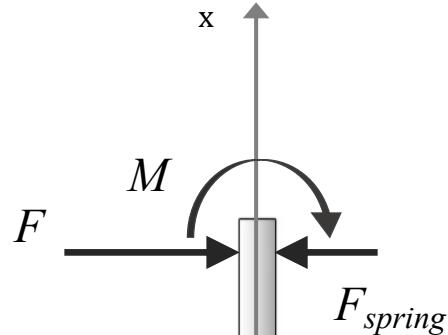
$L_m$  : Mast length (m)



Drag Coefficient as a Function of the Reynolds Number  
Ref. 7)



## FE-modeling

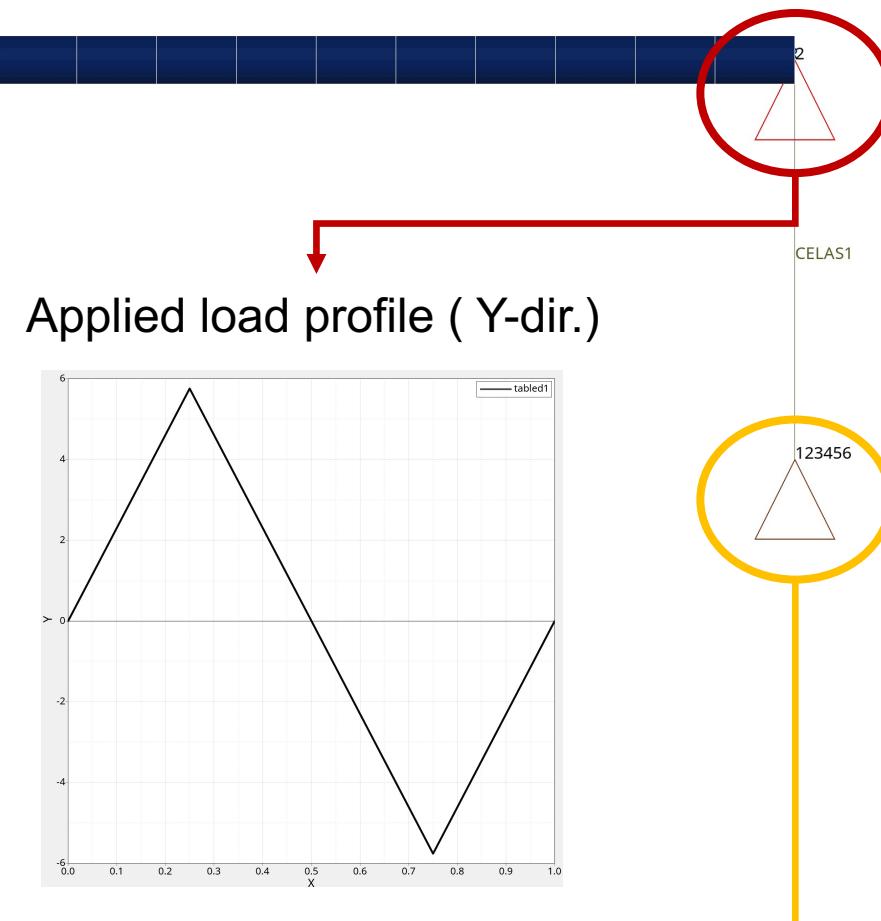
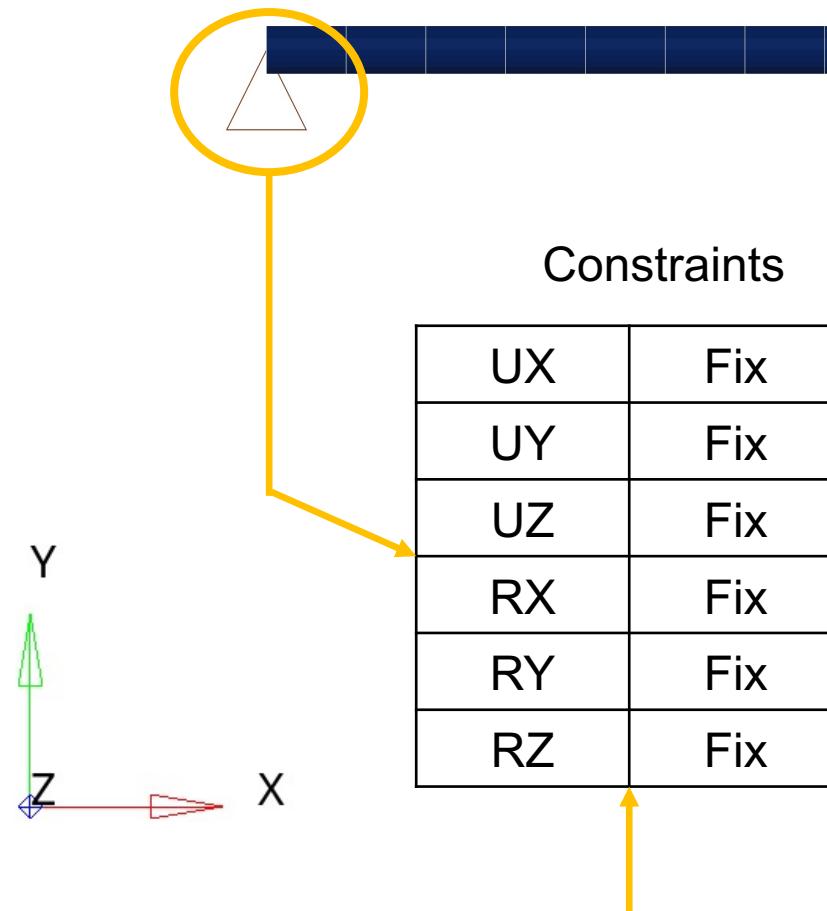


Finite element model

Material properties of rod

| $E$ (GPa) | $\nu$ (Poisson's ratio) | $k$ (N/m) |
|-----------|-------------------------|-----------|
| CFRP      | 14.5                    | -         |
| SPRING    | -                       | 100       |

## Boundary condition



# Analysis

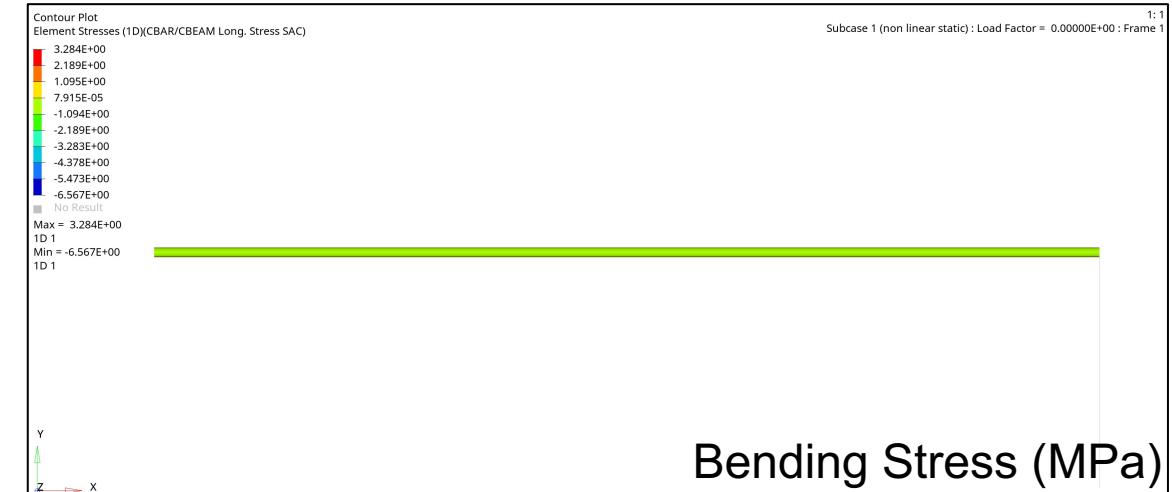
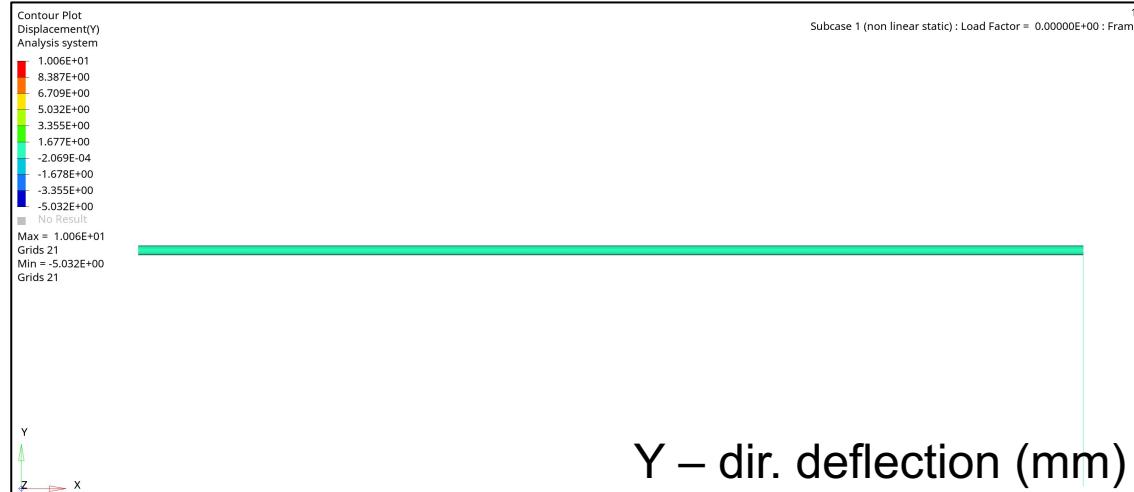
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## Result of bending stress analysis



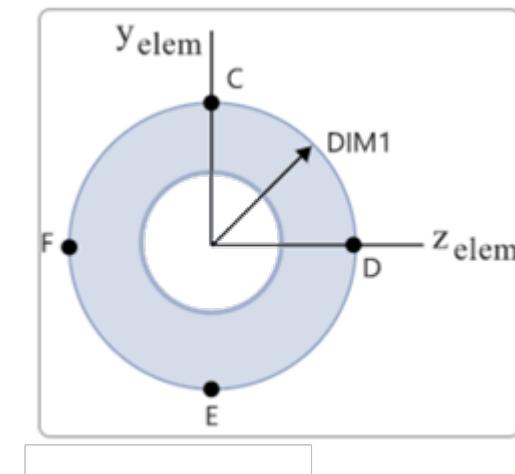
Analysis type - Non-linear static

Result type

Element stresses (1D) - CBAR/CBEAM Long. Stress

SAC or SAE

DISPLACEMENT (V) - Y – dir.



## Energy

Energy = Force × Distance

$$f_{energy} = f_{aerodynamic\ force}(\text{N}) \times f_{\delta}(\text{m}) (\text{Joul})$$

$$f_{aerodynamic\ force} = F + F_M = 2 \int_{L_r}^{L_r + L_m} \frac{1}{2} \rho V^2 C_D D_m(x) dx$$

$f_{\delta}$ =Surrogate model of deflection



$\rho$  : Air density ( $\text{Kg/m}^3$ )

$V$  : Velocity ( $\text{m/s}$ )

$C_D$  : Drag coefficient

$D_m$  : Mast diameter ( $\text{m}$ )

$\delta$  : Deflection

# Optimization

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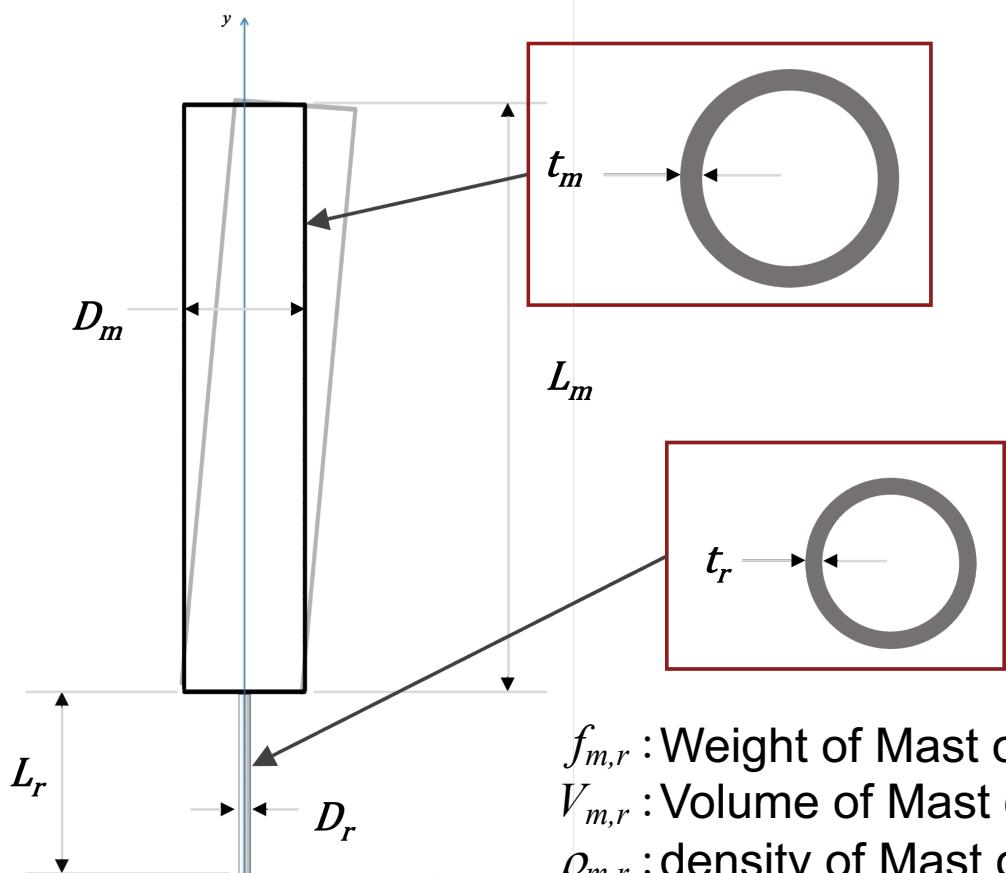
## Total weight of BWG

$$f_{total\ weight} = W_m + W_r \text{ (kg)}$$

$$W_{m,r} = v_{m,r} \times \rho_{m,r}$$

$$v_{m,r} = A_{m,r} \times L_{m,r}$$

$$A_{m,r} = \frac{\pi[D_{m,r}^2 - (D_{m,r} - 2t_{m,r})^2]}{4}$$



- $f_{m,r}$  : Weight of Mast or Rod
- $V_{m,r}$  : Volume of Mast or Rod
- $\rho_{m,r}$  : density of Mast or Rod
- $A_{m,r}$  : Area of Mast or Rod
- $L_{m,r}$  : Length of Mast or Rod
- $D_{m,r}$  : Diameter of Mast or Rod
- $t_{m,r}$  : thickness of Mast or Rod

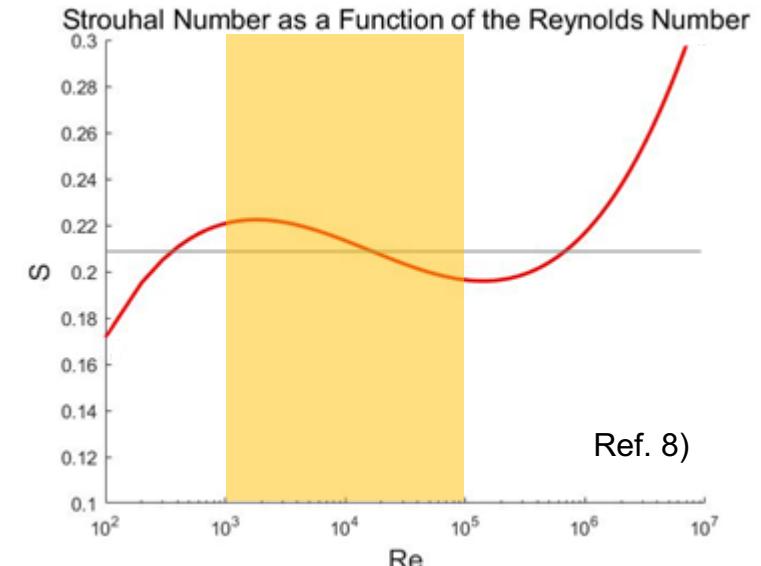
## Resonance condition

$$\frac{\omega_s}{\omega_n} \approx 1 \text{ (Dimensionless numbers)}$$

$$\omega_s = S \frac{V}{D_m} \text{ (Vortex shedding frequency)}$$

$$\omega_n = (\beta_1 L_m)^2 \sqrt{\frac{E_m I_m}{\rho_m A_m L_m^4}} \text{ (Natural frequency)}$$

$$I_m = \frac{\pi [D_m^4 - (D_m - 2t_m)^4]}{32}, \quad A_m = \frac{\pi [D_m^2 - (D_m - 2t_m)^2]}{4}$$



$V$  : Velocity (m/s)

$S$  : Strouhal number

$D_m$  : Mast diameter (m)

$E_m$  : Mast Young's modulus (GPa)

$I_m$  : Inertial moment of mast ( $\text{m}^4$ )

$L_m$  : Mast length (m)

$(\beta_1 L_m)^2$  : 3.52 (constant)<sup>3)</sup>

$\rho_m$  : Mast density ( $\text{kg/m}^3$ )

$A_m$  : Mast area ( $\text{m}^2$ )

Table 1 Design Variables

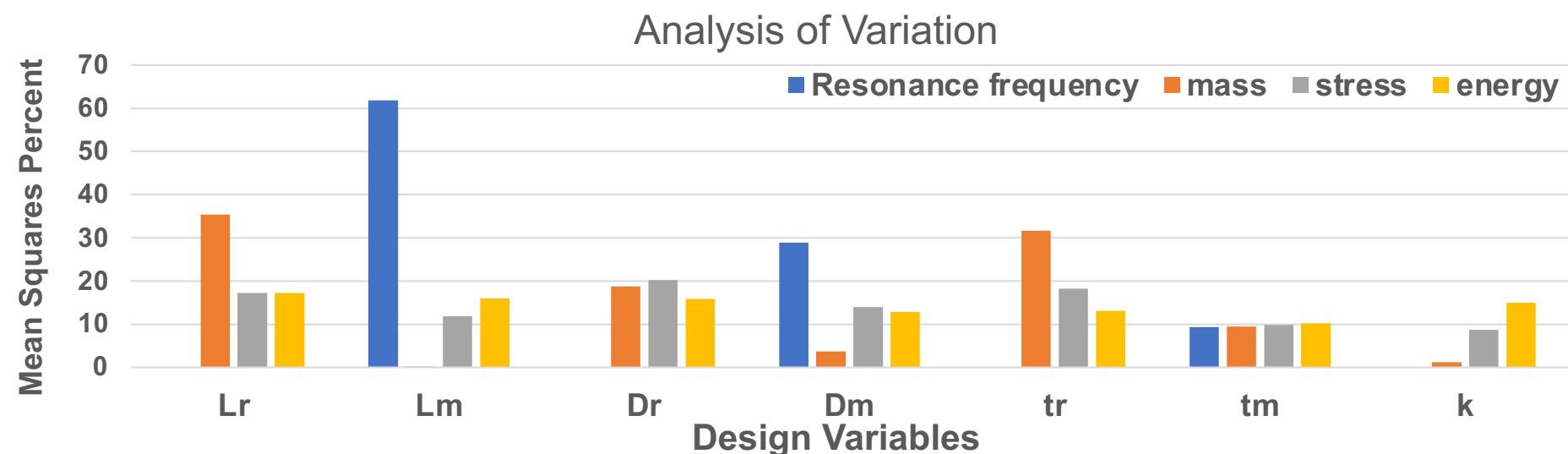
| Label            | Name  | Low Bound | Nominal (Initial) | Upper Bound | Unit |
|------------------|-------|-----------|-------------------|-------------|------|
| Rod Length       | $L_r$ | 0.500     | 1.000             | 1.500       | m    |
| Mast Length      | $L_m$ | 3.000     | 4.000             | 5.000       | m    |
| Rod Diameter     | $D_r$ | 0.020     | 0.020             | 0.040       | m    |
| Mast Diameter    | $D_m$ | 0.400     | 0.600             | 0.600       | m    |
| Rod thickness    | $t_r$ | 0.001     | 0.002             | 0.003       | m    |
| Mast thickness   | $t_m$ | 0.001     | 0.002             | 0.003       | m    |
| Spring stiffness | $k$   | 100.0     | 100.0             | 300.0       | N/m  |

Table 2 Problem Parameters

| Label                       | Name     | Constant | Unit              |
|-----------------------------|----------|----------|-------------------|
| Velocity                    | $V$      | 2.0000   | m/s               |
| Young's modulus of the rod  | $E_r$    | 14.500   | GPa               |
| Young's modulus of the mast | $E_m$    | 72.000   | GPa               |
| Mass density of the rod     | $\rho_r$ | 19,000   | Kg/m <sup>3</sup> |
| Mass density of the mast    | $\rho_m$ | 2,575    | Kg/m <sup>3</sup> |
| Strouhal number             | $S$      | 0.2100   | dimensionless     |
| Drag coefficient            | $C_d$    | 1.0000   | dimensionless     |

## Design of Experiments (DoE) – Taguchi ( $L_8 2^7$ )

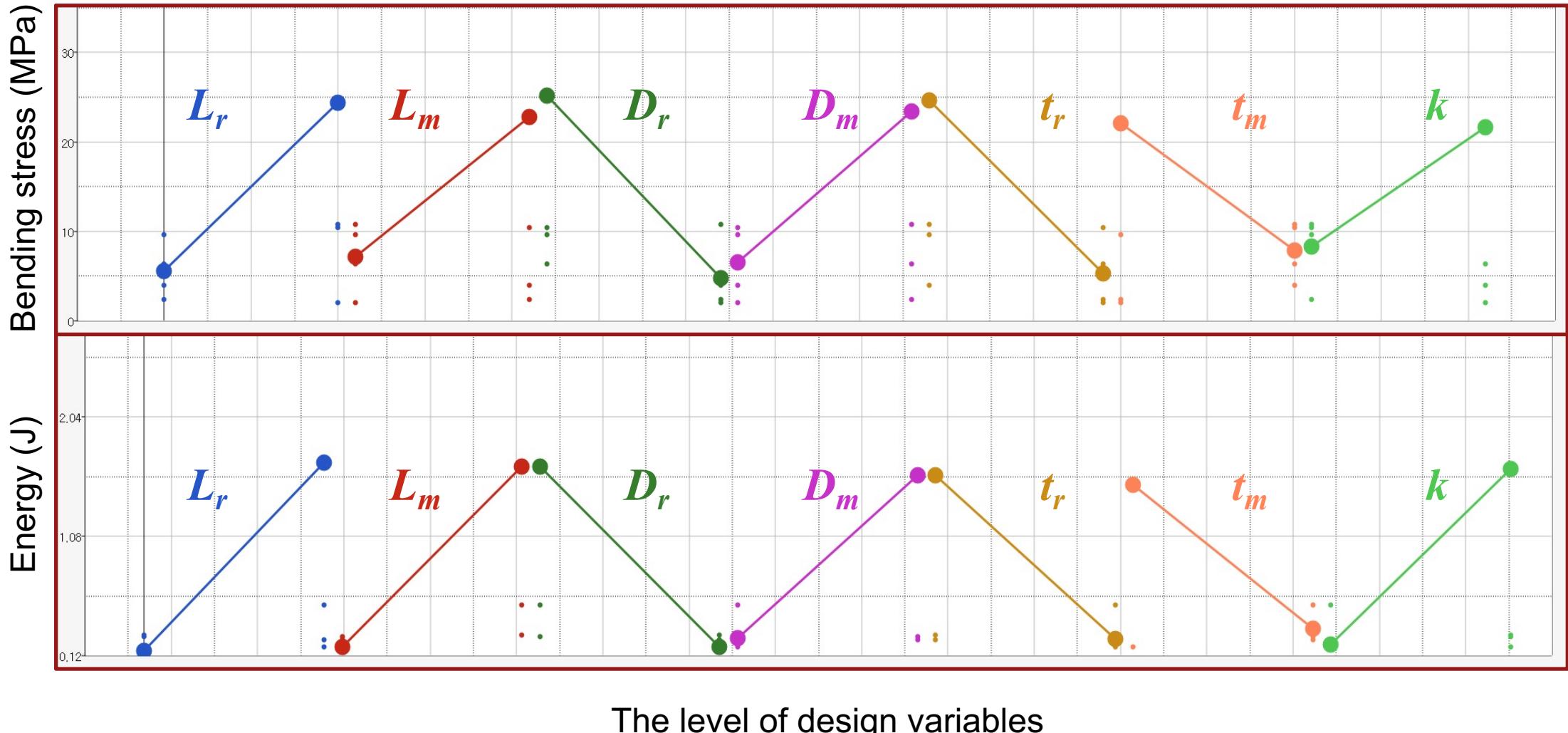
| Run# | $L_r$ | $L_m$ | $D_r$ | $D_m$ | $t_r$ | $t_m$ | $k$ | Resonance frequency | Mass   | Bending stress | Energy |
|------|-------|-------|-------|-------|-------|-------|-----|---------------------|--------|----------------|--------|
| 1    | 0.5   | 3     | 0.02  | 0.4   | 0.001 | 0.001 | 100 | 4.410               | 15.350 | -9.640         | 0.038  |
| 2    | 0.5   | 3     | 0.02  | 0.6   | 0.003 | 0.003 | 300 | 1.960               | 58.690 | -6.330         | 0.274  |
| 3    | 0.5   | 5     | 0.04  | 0.4   | 0.001 | 0.003 | 300 | 15.89               | 59.810 | -3.970         | 0.287  |
| 4    | 0.5   | 5     | 0.04  | 0.6   | 0.003 | 0.001 | 100 | 7.020               | 57.360 | -2.390         | 0.034  |
| 5    | 1.5   | 3     | 0.04  | 0.4   | 0.003 | 0.001 | 300 | 4.410               | 109.07 | -2.030         | 0.192  |
| 6    | 1.5   | 3     | 0.04  | 0.6   | 0.001 | 0.003 | 100 | 1.960               | 78.380 | -10.75         | 0.246  |
| 7    | 1.5   | 5     | 0.02  | 0.4   | 0.003 | 0.003 | 100 | 15.89               | 93.840 | -10.43         | 0.526  |
| 8    | 1.5   | 5     | 0.02  | 0.6   | 0.001 | 0.001 | 300 | 7.019               | 41.240 | -74.30         | 5.718  |



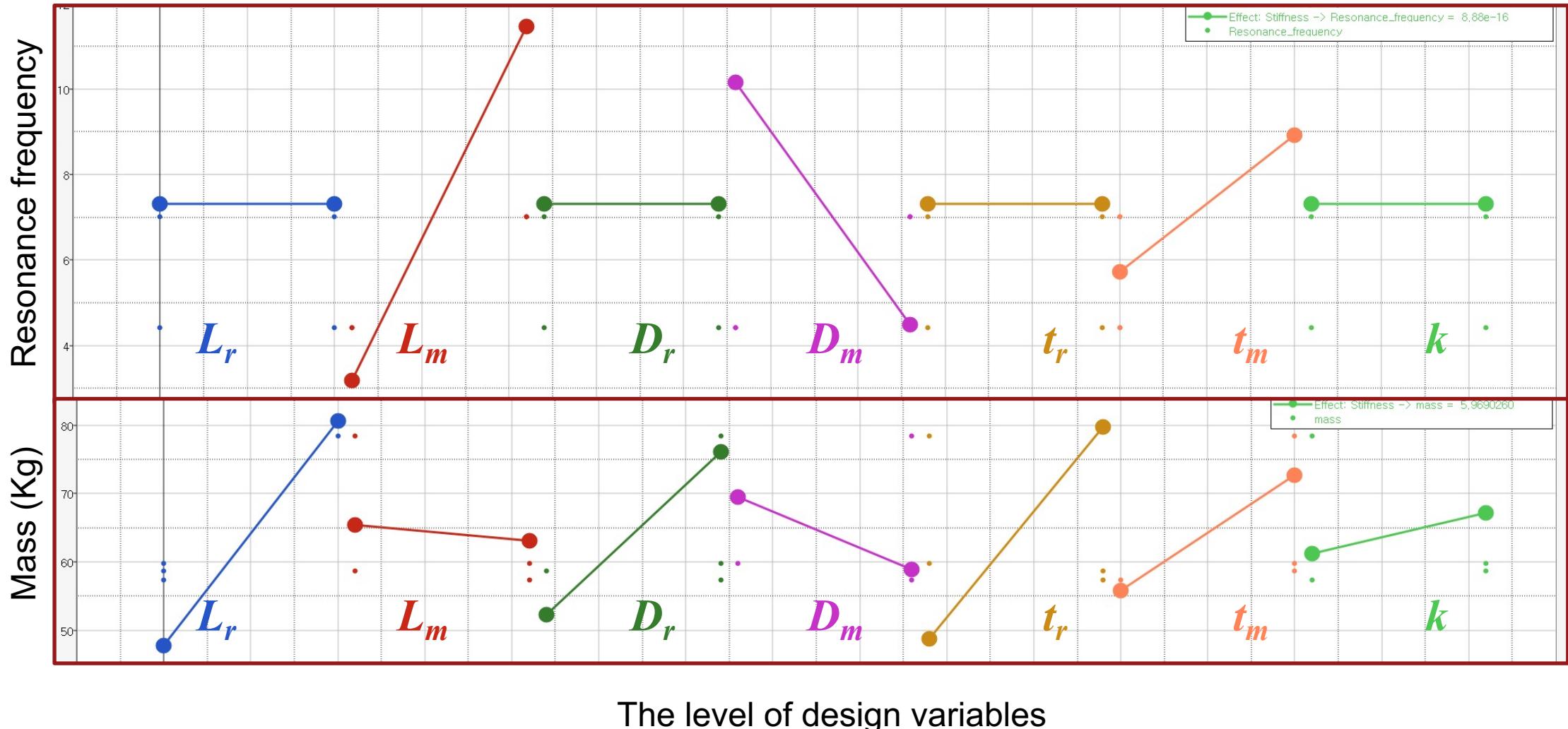
# Optimization

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## Analysis of linear effects – Bending stress & Energy



## Analysis of linear effects - Resonance frequency & Mass



## Design of Experiments (DoE) – Box Behnken (3<sup>7</sup>)

|    | L_r       | L_m       | D_r       | D_m       | t_r       | t_m       | k         |
|----|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 27 | 0.7423268 | 3.0008317 | 0.0205677 | 0.5936640 | 0.0010430 | 0.0010092 | 104.26627 |
| 36 | 1.4843383 | 3.0194885 | 0.0238845 | 0.5993803 | 0.0010516 | 0.0010894 | 268.59693 |
| 37 | 0.7935235 | 3.0202824 | 0.0205982 | 0.5990376 | 0.0010245 | 0.0010004 | 128.11423 |
| 43 | 0.5140283 | 3.0005635 | 0.0200000 | 0.5947234 | 0.0010000 | 0.0010001 | 100.00800 |
| 49 | 0.5629298 | 3.0000007 | 0.0200000 | 0.5999994 | 0.0010000 | 0.0010000 | 100.00009 |
| 51 | 0.6267492 | 3.0001537 | 0.0200830 | 0.5997951 | 0.0010001 | 0.0010000 | 100.16072 |
| 56 | 1.4925376 | 3.0108141 | 0.0200148 | 0.5983947 | 0.0022871 | 0.0017880 | 110.83695 |
| 61 | 0.5260487 | 3.0012652 | 0.0200120 | 0.5999704 | 0.0010001 | 0.0010003 | 100.02666 |
| 62 | 0.5000007 | 3.0000001 | 0.0200000 | 0.5938925 | 0.0010000 | 0.0010000 | 299.97534 |
| 63 | 1.0173182 | 3.0011100 | 0.0200451 | 0.5968437 | 0.0010029 | 0.0010047 | 208.94892 |
| 66 | 1.4717435 | 3.0001621 | 0.0217917 | 0.5999464 | 0.0010805 | 0.0010241 | 298.47020 |
| 69 | 0.5679037 | 3.0002228 | 0.0200202 | 0.5938506 | 0.0010011 | 0.0010034 | 100.00126 |
| 72 | 1.4705886 | 3.0011942 | 0.0217158 | 0.5992664 | 0.0016181 | 0.0010055 | 193.52962 |
| 73 | 0.9654190 | 3.0000130 | 0.0200028 | 0.5999995 | 0.0010002 | 0.0010005 | 195.41781 |
| 75 | 0.6941120 | 3.0015619 | 0.0202527 | 0.5985150 | 0.0010011 | 0.0010039 | 107.87091 |
| 78 | 1.3140468 | 3.0249667 | 0.0200171 | 0.5999779 | 0.0010021 | 0.0010039 | 299.22019 |
| 79 | 1.3929551 | 3.0000066 | 0.0211637 | 0.5993562 | 0.0010023 | 0.0010054 | 299.78527 |
| 81 | 0.5128292 | 3.0002619 | 0.0200024 | 0.5997898 | 0.0010012 | 0.0010000 | 100.12916 |
| 90 | 0.8516842 | 3.0004437 | 0.0204168 | 0.5964396 | 0.0010054 | 0.0010003 | 150.37571 |
| 91 | 0.5013722 | 3.0002708 | 0.0200123 | 0.5964041 | 0.0010017 | 0.0010014 | 284.32069 |
| 93 | 0.6855141 | 3.0000020 | 0.0200002 | 0.5998054 | 0.0010186 | 0.0010040 | 111.51079 |
| 78 | 1.3140468 | 3.0249667 | 0.0200171 | 0.5999779 | 0.0010021 | 0.0010039 | 299.22019 |
| 79 | 1.3929551 | 3.0000066 | 0.0211637 | 0.5993562 | 0.0010023 | 0.0010054 | 299.78527 |
| 81 | 0.5128292 | 3.0002619 | 0.0200024 | 0.5997898 | 0.0010012 | 0.0010000 | 100.12916 |
| 90 | 0.8516842 | 3.0004437 | 0.0204168 | 0.5964396 | 0.0010054 | 0.0010003 | 150.37571 |
| 91 | 0.5013722 | 3.0002708 | 0.0200123 | 0.5964041 | 0.0010017 | 0.0010014 | 284.32069 |
| 93 | 0.6855141 | 3.0000020 | 0.0200002 | 0.5998054 | 0.0010186 | 0.0010040 | 111.51079 |

Removed outlier  
and duplicated sample point



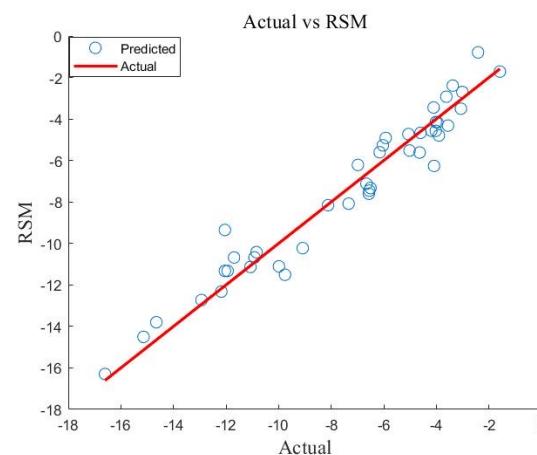
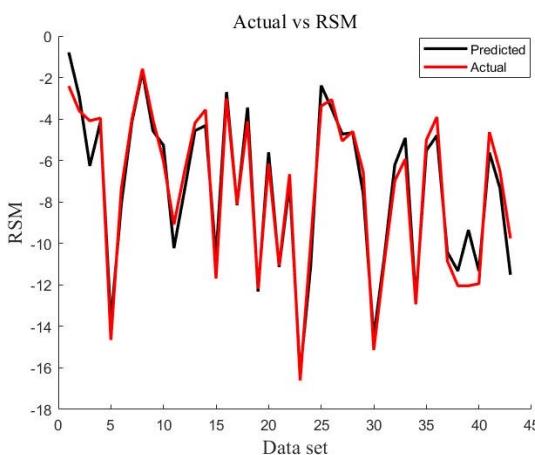
|    | L_r | L_m | D_r  | D_m | t_r   | t_s   | k   |
|----|-----|-----|------|-----|-------|-------|-----|
| 1  | 0.5 | 3   | 0.03 | 0.4 | 0.002 | 0.002 | 200 |
| 2  | 0.5 | 3   | 0.03 | 0.6 | 0.002 | 0.002 | 200 |
| 3  | 0.5 | 4   | 0.03 | 0.5 | 0.002 | 0.001 | 100 |
| 4  | 0.5 | 4   | 0.03 | 0.5 | 0.002 | 0.001 | 300 |
| 5  | 0.5 | 4   | 0.02 | 0.5 | 0.001 | 0.002 | 200 |
| 6  | 0.5 | 4   | 0.02 | 0.5 | 0.003 | 0.002 | 200 |
| 7  | 0.5 | 4   | 0.04 | 0.5 | 0.001 | 0.002 | 200 |
| 8  | 0.5 | 4   | 0.04 | 0.5 | 0.003 | 0.002 | 200 |
| 9  | 0.5 | 5   | 0.03 | 0.4 | 0.002 | 0.002 | 200 |
| 10 | 0.5 | 5   | 0.03 | 0.6 | 0.002 | 0.002 | 200 |
| 11 | 1   | 3   | 0.03 | 0.5 | 0.001 | 0.002 | 100 |
| 12 | 1   | 3   | 0.03 | 0.5 | 0.001 | 0.002 | 300 |
| 13 | 1   | 3   | 0.03 | 0.5 | 0.003 | 0.002 | 100 |
| 14 | 1   | 3   | 0.03 | 0.5 | 0.003 | 0.002 | 300 |
| 15 | 1   | 3   | 0.02 | 0.5 | 0.002 | 0.001 | 200 |
| 16 | 1   | 3   | 0.04 | 0.5 | 0.002 | 0.001 | 200 |
| 17 | 1   | 4   | 0.03 | 0.4 | 0.001 | 0.001 | 200 |
| 18 | 1   | 4   | 0.03 | 0.4 | 0.003 | 0.001 | 200 |
| 19 | 1   | 4   | 0.03 | 0.6 | 0.001 | 0.001 | 200 |
| 20 | 1   | 4   | 0.03 | 0.6 | 0.003 | 0.001 | 200 |
| 21 | 1   | 4   | 0.02 | 0.4 | 0.002 | 0.002 | 100 |
| 37 | 1.5 | 3   | 0.03 | 0.6 | 0.002 | 0.002 | 200 |
| 38 | 1.5 | 4   | 0.03 | 0.5 | 0.002 | 0.001 | 100 |
| 39 | 1.5 | 4   | 0.03 | 0.5 | 0.002 | 0.001 | 300 |
| 40 | 1.5 | 4   | 0.04 | 0.5 | 0.001 | 0.002 | 200 |
| 41 | 1.5 | 4   | 0.04 | 0.5 | 0.003 | 0.002 | 200 |
| 42 | 1.5 | 5   | 0.03 | 0.4 | 0.002 | 0.002 | 200 |
| 43 | 1.5 | 5   | 0.03 | 0.6 | 0.002 | 0.002 | 200 |

Box Behnken

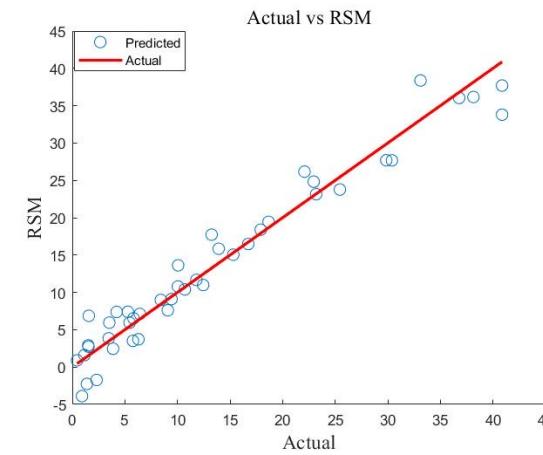
Modified

## Surrogate model - second-order polynomial function

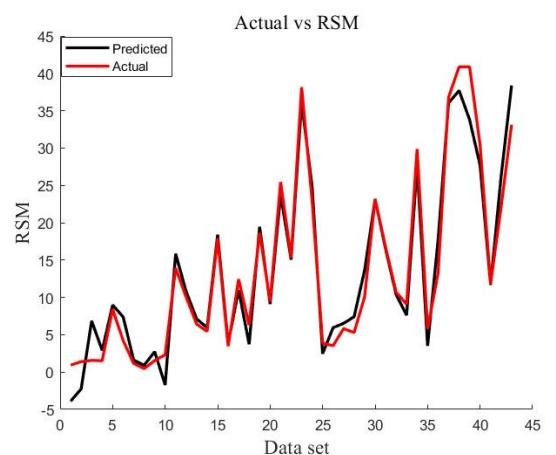
$$g_n(x_1, \dots, x_n) = \beta_0 + \sum_{i=1}^n \beta_i x_i + \sum_{i=1}^n \beta_i x_i^2 + \sum_{i < j} \sum_{j=1}^n \beta_{ij} x_i x_j$$



Bending Stress ( $R^2=0.986$ )



Deflection ( $R^2=0.9746$ )



# Optimization

Introduction

Modeling

**Analysis & Optimization**

Conclusion

$$\text{Max. } f_{\text{energy}} = f_{\text{aerodynamic force}}(\text{N}) \times f_{\delta}(\text{m}) \text{ (Joule)}$$

$$\text{Min. } f_{\text{total weight}} = W_m + W_r \text{ (Kg)}$$

subject to.  $\frac{g_{\text{bending stress}}}{16.6 \text{ MPa}} - 1 \leq 0$

$$g_{\text{resonance frequency}_1} = 1 - \frac{\omega_s}{\omega_n} \leq 0 \text{ (dimensionless numbers)}$$

$$g_{\text{resonance frequency}_2} = \frac{\omega_s}{2\omega_n} - 1 \leq 0 \text{ (dimensionless numbers)}$$

Where,

$f_{\delta}$  (m): surrogate model of deflection

$g_{\text{bending stress}}$  (MPa): surrogate model of bending stress

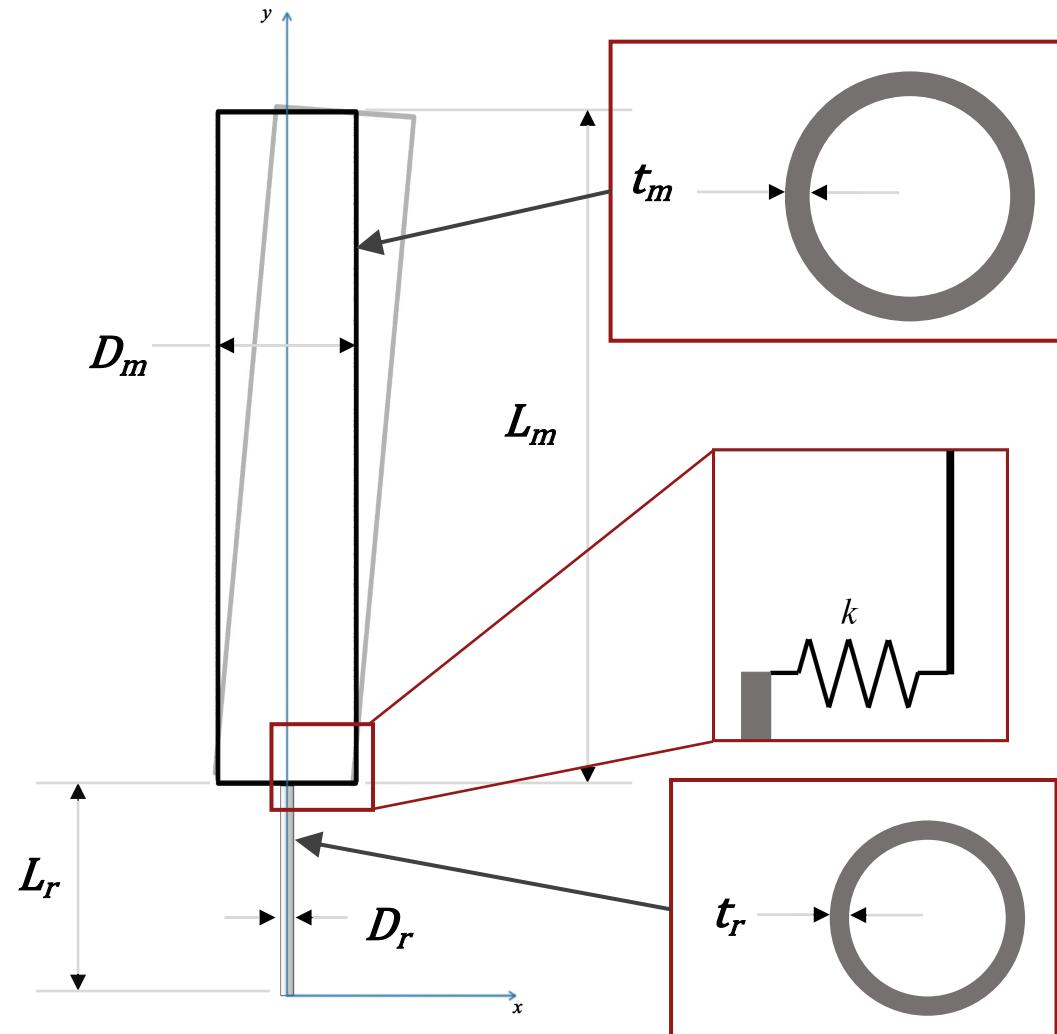
Design variable:

$$0.5 \leq L_r \leq 1.5 \text{ (m)}, 3 \leq L_m \leq 5 \text{ (m)}, 0.02 \leq D_r \leq 0.04 \text{ (m)}, 0.4 \leq D_m \leq 0.6 \text{ (m)}$$

$$0.001 \leq t_r \leq 0.003 \text{ (m)}, 0.001 \leq t_m \leq 0.003 \text{ (m)}, 100 \leq k \leq 300 \text{ (N/m)}$$

Initial parameters:  $[L_r, L_m, D_r, D_m, t_r, t_m, k] = [1, 4, 0.02, 0.6, 0.002, 0.002, 100]$

Problem parameters:  $V = 2 \text{ m/s}$ ,  $E_r = 14.5 \text{ (GPa)}$ ,  $E_m = 72 \text{ (GPa)}$ ,  $\rho_r = 19,000 \text{ (kg/m}^3)$ ,  $\rho_m = 2,575 \text{ (kg/m}^3)$ ,  $S = 0.21$ ,  $C_d = 1$



# Optimization

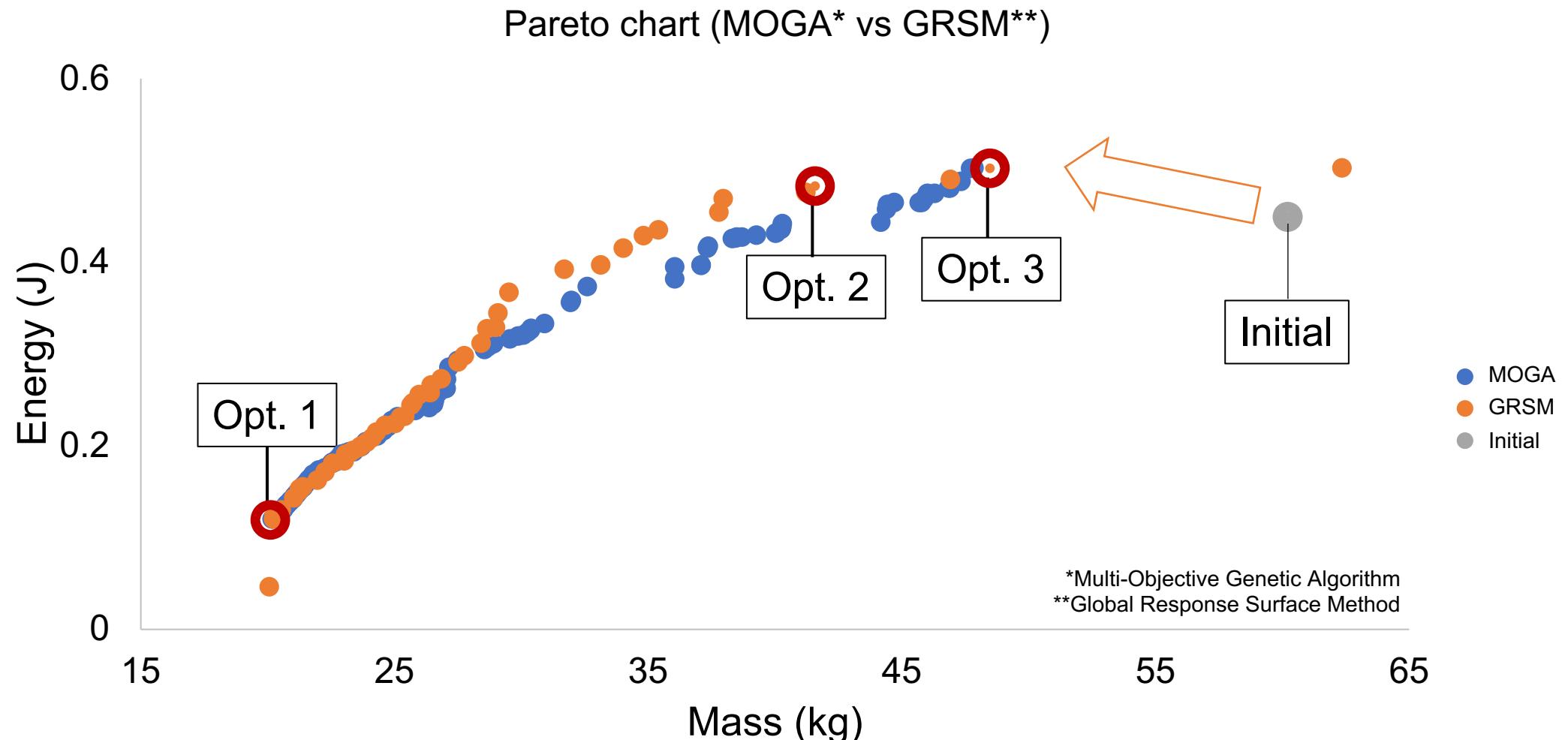
Introduction

Modeling

Analysis &amp; Optimization

Conclusion

## Pareto chart



## HyperStudy – Optimization (Global Response Search Method)

### Optimal Design Variables

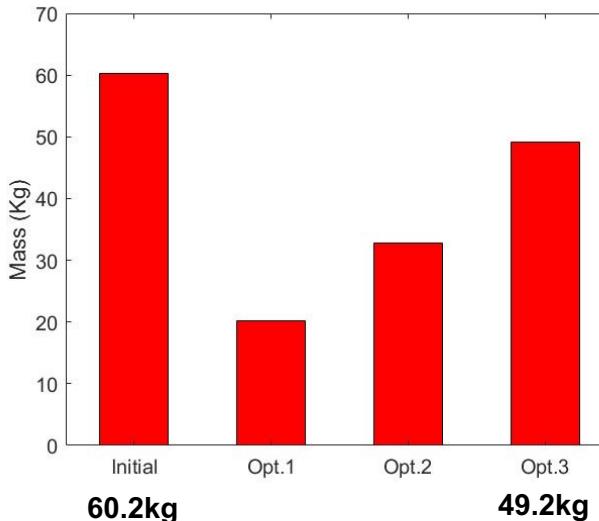
|         | $L_r$ (m) | $L_m$ (m) | $D_r$ (m) | $D_m$ (m) | $t_r$ (m) | $t_m$ (m) | $k$ (N/m) |
|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Initial | 1.000     | 4.000     | 0.02      | 0.6000    | 0.002     | 0.002     | 100.000   |
| Opt. 1  | 0.500     | 3.000     | 0.02      | 0.5997    | 0.001     | 0.001     | 103.986   |
| Opt. 2  | 1.393     | 3.000     | 0.021164  | 0.5994    | 0.001     | 0.001     | 299.785   |
| Opt. 3  | 1.499     | 3.000     | 0.021244  | 0.5994    | 0.002     | 0.001     | 132.243   |

|         | Objective function |            |                      | Constraint function |             |
|---------|--------------------|------------|----------------------|---------------------|-------------|
|         | Mass (kg)          | Energy (J) | Bending stress (MPa) | resonance 1         | resonance 2 |
| Initial | 60.2               | 0.45       | -3.02489             | 1.012445            | -0.01848    |
| Opt. 1  | 20.2               | 0.12       | -0.06463             | -0.00336            | -0.99327    |
| Opt. 2  | 43.6               | 0.47       | -0.00045             | -0.01835            | -0.963293   |
| Opt. 3  | 49.2               | 0.50       | -0.00444             | -0.01893            | -0.96254    |

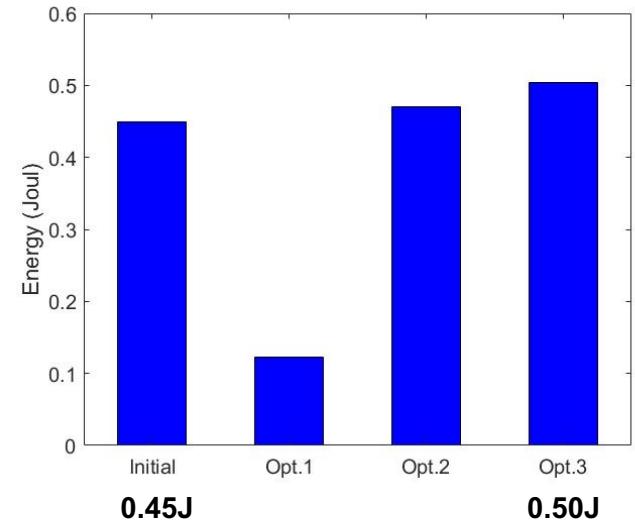
# 4. Conclusion

# Conclusion

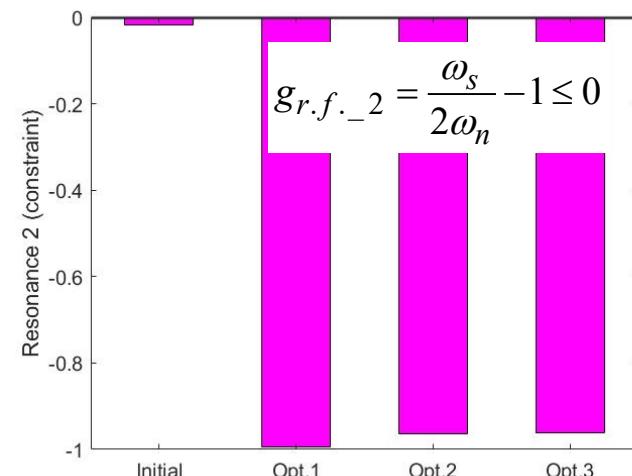
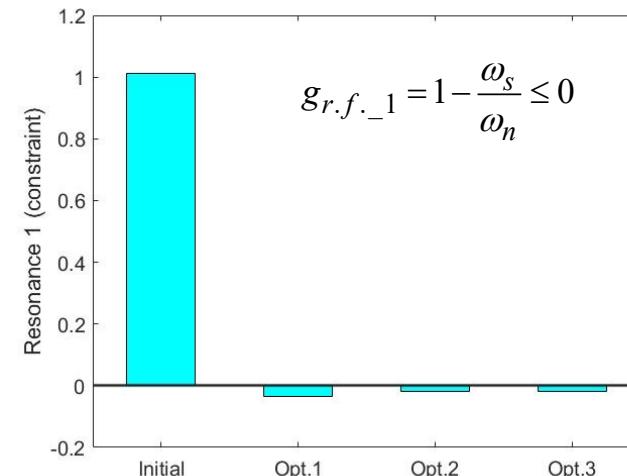
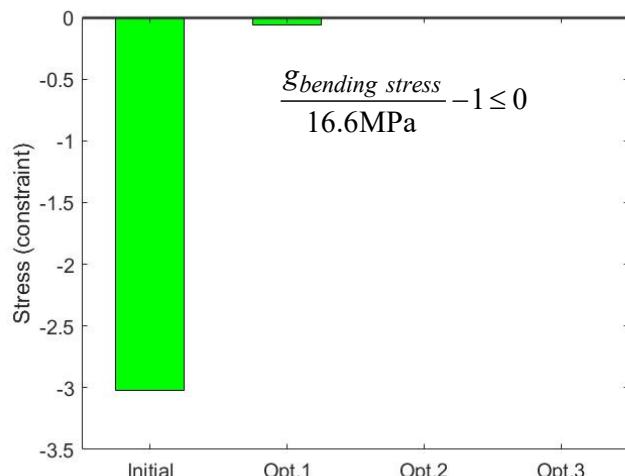
**Mass : decreased by 18.3%**



**Energy : increased by 10%**



**Satisfaction of all constraint functions**





# Q & A

## Thank you!

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Figure 1: neelam279. Wind generator Photo. 21 Feb 2020. Pixabay.

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Figure 2: vortexbladeless. [@vortexbladeless]. Photo of BWG. *Instagram*, 28 Jen. 2021,

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Figure 4: vortexbladeless. [@vortexbladeless]. Photo of BWG. *Instagram*, 31 Jul. 2019,

[https://www.instagram.com/p/B0ITzuzigN3/?utm\\_source=ig\\_web\\_copy\\_link\(Vortex](https://www.instagram.com/p/B0ITzuzigN3/?utm_source=ig_web_copy_link(Vortex)

Figure 5: Vortex Bladeless Wind Power. "Vortex Bladeless How it Works, scheme(2020)." Online video clip. YouTube, 27 Nov. 2021. web. 16 Aug. 2021.

Figure 6: Wikipedia contributors. "Vortex shedding." *Wikipedia, The Free Encyclopedia*. Wikipedia, The Free Encyclopedia, 16 Jul. 2021. Web. 16 Aug. 2021.

## BWG\_optimization.hstudy

▶  Error\_DOE

▶  Error\_Fit

 Report 

Show in Explorer

|   | Active                              | Label                   | Varname               | Description                                                      | Periodic                            |
|---|-------------------------------------|-------------------------|-----------------------|------------------------------------------------------------------|-------------------------------------|
| 1 | <input type="checkbox"/>            | Approach Specific Files | hst_approach_specific | Generates files like .sylk, anova, fit diagnostics               | <input type="checkbox"/>            |
| 2 | <input checked="" type="checkbox"/> | HyperStudy Data         | hst_data              | Generate data report (*.data)                                    | <input type="checkbox"/>            |
| 3 | <input type="checkbox"/>            | HyperStudy HTML         | hst_html              | Generate HTML report (*.htm)                                     | <input type="checkbox"/>            |
| 4 | <input type="checkbox"/>            | HyperWorks Session      | hst_hwmvw             | Generate HyperWorks report (*.mwv) - (Not available in batch)    | <input type="checkbox"/>            |
| 5 | <input type="checkbox"/>            | Knowledge Studio Text   | hst_kstext            | Export data compatible with Altair Knowledge Studio text import  | <input type="checkbox"/>            |
| 6 | <input type="checkbox"/>            | Knowledge Studio .xlsx  | hst_xsxlsx            | Export data compatible with Altair Knowledge Studio Excel import | <input type="checkbox"/>            |
| 7 | <input type="checkbox"/>            | HyperStudy Fit          | hst_pythonfit         | Generate input file for HyperStudy Fit model (*.pyfit)           | <input type="checkbox"/>            |
| 8 | <input type="checkbox"/>            | HyperStudy Spreadsheet  | hst_xls               | Generate Spreadsheet report (*.xls, *.xlsx)                      | <input type="checkbox"/>            |
| 9 | <input type="checkbox"/>            | Periodic Export example | hst_report_periodic   | Generate output periodically during an evaluation                | <input checked="" type="checkbox"/> |

 Create Report

Report시 rpt폴더내에 파일이 생성되지 않고  
프로그램이 종료되는 현상이 발생

MATLAB을 이용하여 대리모델 생성